APPENDIX A

DESIGN REPORT
(Technical Appendix)

FOR THE

PHASE II, REPORT
DREDGED MATERIAL MANAGEMENT PLAN
UPPER SAGINAW RIVER, MICHIGAN

UPPER SAGINAW RIVER, MICHIGAN
DREDGED MATERIAL MANAGEMENT PLAN (DMMP)

TECHNICAL APPENDIX (A)

U.S. ARMY CORPS OF ENGINEERS
DETROIT DISTRICT
JULY 2004

UPPER SAGINAW RIVER, MICHIGAN
DREDGED MATERIAL MANAGEMENT PLAN (DMMP)
TECHNICAL APPENDIX (A)

TABLE OF CONTENTS

UPPER SAGINAW RIVER, MICHIGAN
DREDGED MATERIAL MANAGEMENT PLAN (DMMP)
TECHNICAL APPENDIX (A)

INTRODUCTION

A. PURPOSE AND SCOPE OF STUDY. The purpose of this appendix is to present detailed engineering and design data for the Upper Saginaw River, Michigan Dredged Material Placement Site (DMPS) project. This appendix provides the basis for the preparation of plans and specifications for construction of the DMPS. Description of procedures and basic supporting data related to investigations made in connection with the preparation of this appendix are presented in the paragraphs and figures to follow. This engineering and design is being accomplished under the National Harbors Program: Dredged Materials Management Plan (DMMP).

B. BACKGROUND. Since the latter part of the 1970's, materials from the upper reaches of the Saginaw River were placed in the Middleground Island Confined Disposal Area and those from the lower river were placed in the Saginaw Bay Confined Disposal Area. The Middleground Island Facility was filled and returned to the local sponsor in 1984. Dredging in the Upper River was reduced with only the critical shoals being removed and placed in the Bay CDF at additional expense due to the greater haul distance.

Two sites have been identified for analysis in this appendix. One alternative site for placement of dredged materials has been identified at a location in Buena Vista/ Zilwaukee Township, west of the Saginaw River, approximately 11 miles upstream of the mouth of Saginaw River, in the city of Bay City, Michigan. See Figure 1 for the project location and vicinity maps. The site which lies adjacent to and west of the Saginaw River encompasses a total area of approximately 581 acres. The second alternative site for placement of dredged materials has been identified at a location in Buena Vista/ Zilwaukee Township, approximately 11 miles upstream of the mouth of Saginaw River, in the city of Bay City, Michigan. The site which lies adjacent to and east of the Saginaw River encompasses a total area of approximately 274 acres.

C. DATA COLLECTION. The design data collected during the course of this study has included the following:

1. CADD drawings developed from topographic surveys provided by the Technical Support Section, Detroit District Corps of Engineers used for the plan layout and volume computations.

2. Soil boring investigations by STS Consultants in July 2002 used to develop a representative soil profile of the area and provide data for a stability analysis of the existing dikes and proposed dikes.

3. A list of pertinent references is provided on Page 5 of this document.

DESIGN

A. DESIGN CRITERIA. The design rationale used in this study provides for an efficient least cost plan based on sound engineering practice with proper consideration given to environmental and social aspects. The following parameters were assumed:

- Total Available Capacity of the DMPS is approximately 3,100,000 cubic yards. It is assumed that bulking and consolidation will be the same.

- Confinement dikes would be constructed from on-site clay materials.

- The large area available for containment will permit storage of a high volume of dredged material sediments and transport water without discharge thereby allowing for maximum settling time of the sediments without the need to construct high confinement dikes.

- Dredging may be performed by both mechanical and hydraulic equipment, however it will be assumed that conveyance into the site will be by hydraulic methods.

B. PROJECT FEATURES. The Saginaw River Dredged Material Placement (West) Site (DMPS) is located in Zilwaukee Township, Michigan adjacent to and west of the Saginaw River. The Site Plan is shown on Figure 1. An alternative site evaluated during this study, the Buena Vista Township (East) Site is located east of the Saginaw River approximately 11 miles upstream from the mouth of the Saginaw River. The Site Plan is shown on Figure 3. The total area available for utilization of construction of new dikes for dredged material placement is approximately 281 acres for the west site and 120 acres for the east site. The current plan is to construct one confinement cell within each site. The volume of materials to be dredged and placed during a particular dredging season will depend upon the degree of critical shoaling and the availability of dredging funds, however, it is estimated that average annual maintenance dredging activities would be 150,000 cubic yards per year. Although portions of the east site and the west site are diked, project mitigation and site selection features dictate that higher dikes with engineering materials be constructed in order to permit disposal by hydraulic methods.

Materials for new dike construction would be obtained from borrow areas located within each site. It is anticipated that the borrow areas would be located along the new dike location and excavation would continue along the length of dike. Prior to excavation of materials for new dike construction, a one foot (1.0 ft.) layer of topsoil will be stripped from the proposed borrow area within the confines of the proposed dikes, and either stockpiled or removed from the project area. Any excess excavated material may also be stockpiled or hauled away by the contractor. A chain-link type security fence (Figure 8) will be constructed around the outer perimeter of the placement area.

All confinement dikes will have an minimum ten foot (10.0 ft.) top width and side slopes of 1V:2H. Hydraulically dredged material will be placed into the confinement cell by contractor furnished pipeline. The pipeline will enter the placement area from the river side of the site. Discharge into the confined area would be controlled so as to preclude erosion of the interior dike slopes. A stop-log type weir will be used to control the flow of water discharged from the confinement cell. The discharge will then flow from the weir through a 12 "diameter CMP that will be buried along an easement from the confinement area to the Saginaw River. During the latter years of use of a confinement cell, interior spur dikes can be constructed so as to provide the greatest length of flow within the cell and subsequently the greatest amount of settling time.

C. SITE DESIGN. The Zilwaukee Township (West) is the selected site for this study. The design of the site is simplified by the relatively large area available for confinement. The containment cell will be designed to provide storage for dredged material sediments and associated transport water during the initial dredging season and subsequent dredging cycles. This will allow for maximum settling of the solids to take place and release of the clarified water after a period of time.

In the initial dredging and disposal cycle, assuming 150,000 cubic yards of materials are removed, the total volume of transport water and solids that are to be confined is estimated to be 750,000 cubic yards. This is based on past project experience in the Upper Saginaw River that hydraulically pumped dredged materials which are primarily silty sands and would contain approximately 20% solids and 80% water. Based on these parameters, a minimum dike height of 11.0 ft. including 2.0 ft. of freeboard is required for the west site, and a minimum dike height of 17.0 ft. including 2.0 ft. of freeboard is required for the east site The depth of the remaining sediments after dewatering is estimated to average 0.5 ft. per dredging cycle.

The average ground elevation within the interior areas of the sites is 580.0 ft for the west site, and is 582.0 ft for the east site. New dikes for each site would be constructed of clay materials borrowed from on-site. This clay material would be compacted to ensure insure dike integrity and impermeability. A typical cross section is shown on Figures 4.

The outlet structures would be stop log type weirs for both the east and the west sites. The use of the stop log weir allows operators to manually adjust the water level in the placement area according to the incoming flow conditions. In order to meet water quality requirements for effluent that is discharged from the site, the stop logs would be set in such a manner as to stop any flow out from the site thereby allowing the maximum amount of detention and settling time for solids. Design of the weirs is based on structures that have been constructed and operated at various disposal facilities throughout the Detroit District. The relatively simple design results in efficient fabrication and ease of operation. As noted before, control of water flow and subsequently water levels within an impounded area is afforded by this type of structure. This is necessary due to the importance placed on achieving a specific level of water quality of the effluent that leaves the site and re-enters the waterway.

As previously mentioned in this Appendix, spur dikes could be constructed within the confinement area. The spur dikes would consist of existing dredged sediments and located such that the flow distance from the point of discharge into the site to point of discharge at the weir structure is effectively increased upwards to a factor of two thereby increasing the detention times of the dredged sediments. This will be necessary during the latter periods of operation when the available volume of storage capacity of the site is reduced.

A stability analysis of the proposed new dike configuration for the west site was undertaken in order to assure its integrity under various hydraulic conditions. A stability analysis was not completed for the east site. Data for the analyses was derived from soil borings taken within the proposed placement area as shown on Figure 6. The borings indicate that the surficial geology of the interior of the site is composed of topsoil that consists of sand with varying amounts of silt, sand and gravel with trace roots. The existing access roads and dike systems consist of either a sand and gravel or clay fill. The sand and gravel fill consists of brown medium to coarse sand and generally extends to a depth of 2.0 feet below the topsoil. The clay fill is a brown to gray containing varying amounts of silt, sand and gravel with a very stiff to hard consistency and generally extends to a depth of 2.0 to 8.0 feet. The natural soils at the site consist of a brown medium to stiff silty clay. This clay was brown to gray with varying amounts of silt, sand and fine gravel and generally extend to the termination point of the soil borings at a depth of 25 to 40 feet. A soil profile of the placement area is shown on Figure 7. The Stability Analysis is contained on Pages A17 thru A 30.

<u>REFERENCES</u>

1. U.S. Army, Waterways Experiment Station. January 1976. Mathematical Model for Predicting the Consolidation of Dredged Material in Confined Disposal Areas. Technical Report DS-76-1. Vicksburg, Mississippi.

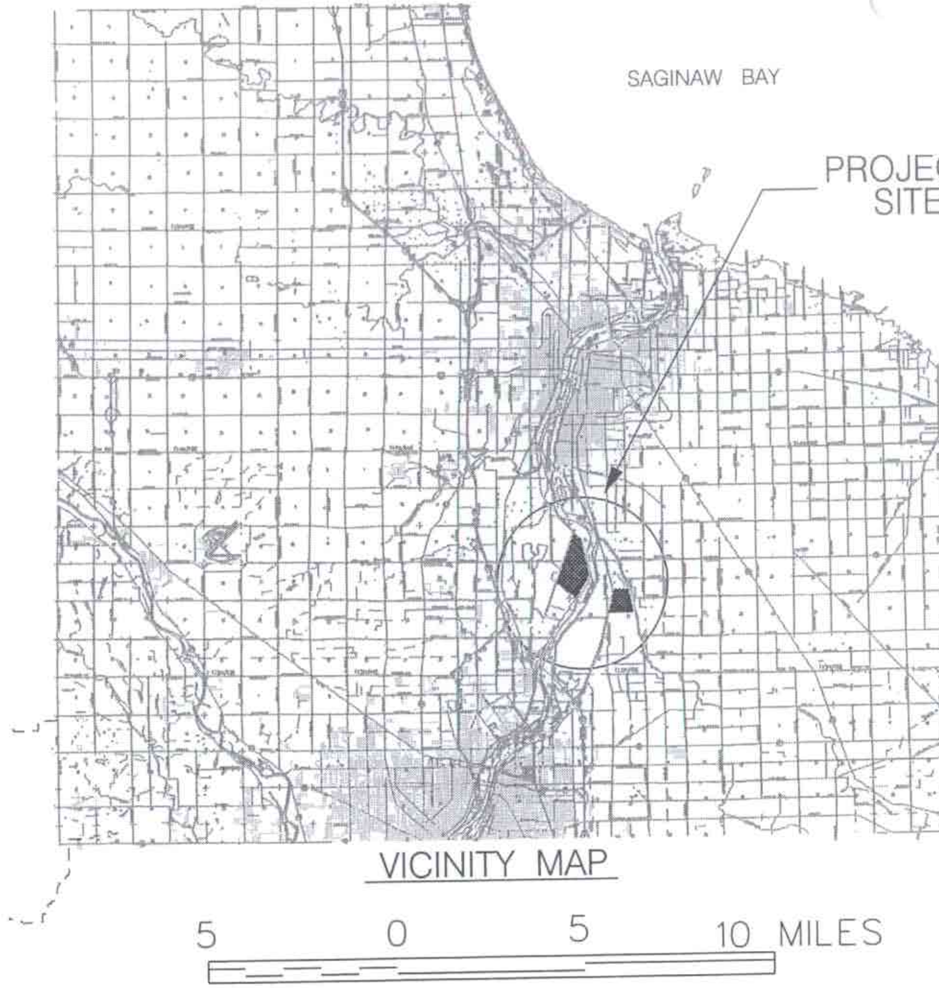
2. U.S Army Engineer District, Savannah. November 1977. Design and Construction of Retaining Dikes for Dredged Material Containment Facilities. Technical Report DS-77-9. Savannah, Georgia.

3. U.S. Army, Waterways Experiment Station. December 1978. Guidelines for Designing, Operating and Managing Dredged Material Containment Areas. Technical Report DS-78-10. Vicksburg, Mississippi.

4. U.S. Army, Office, Chief, of Engineers. April 1970. Stability of Earth and Rock Filled Dams. EM 1110-2-1902. Washington, D.C.

5. U.S. Army, Office, Chief of Engineers. March 1978. Design and Construction of Levees. EM 1110-2-1913. Washington, D.C.

FIGURES



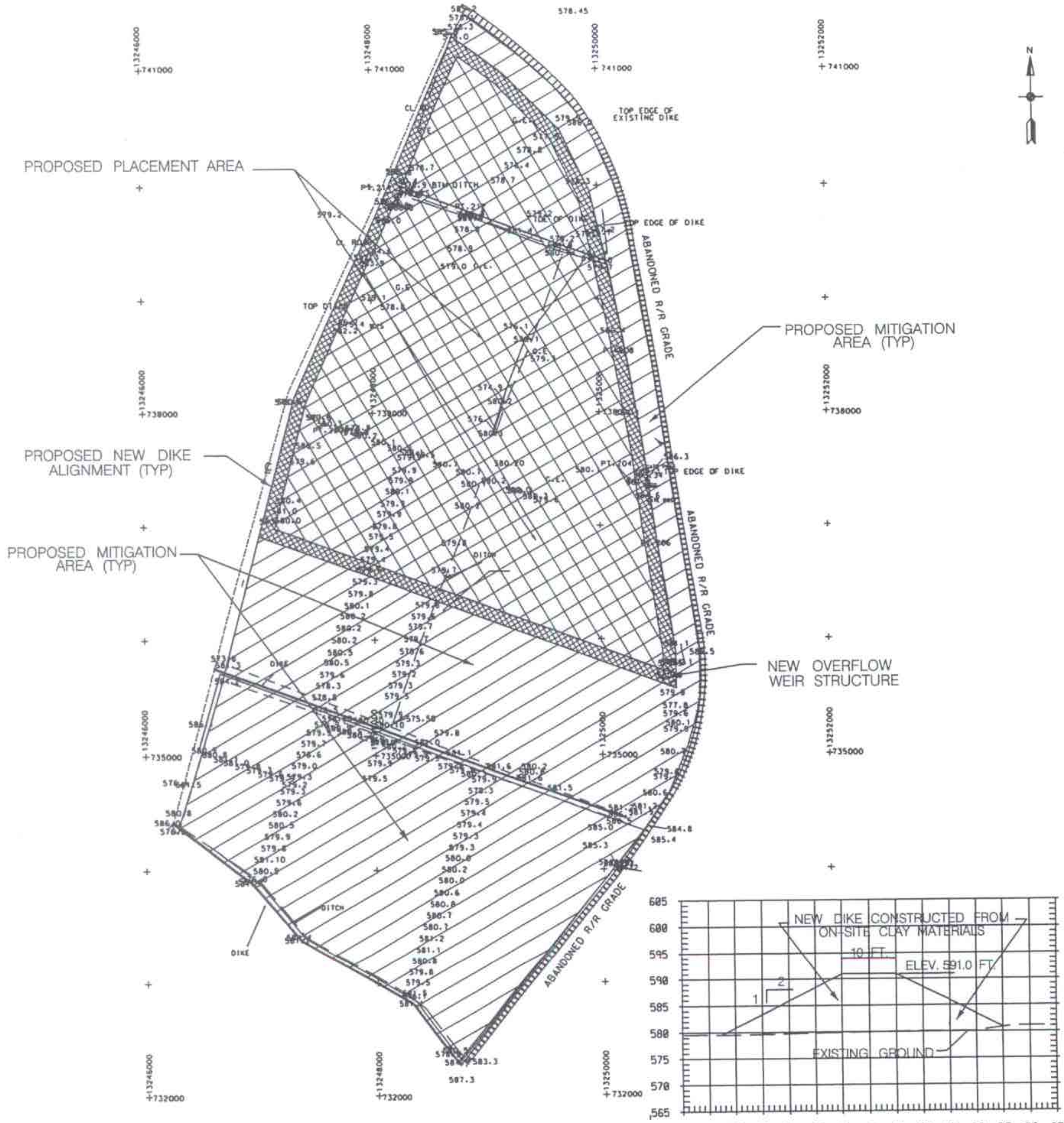
U.S. ARMY ENGINEER DISTRICT, DETROIT
CORPS OF ENGINEERS
DETROIT, MICHIGAN

UPPER SAGINAW RIVER, MICHIGAN

DREDGED MATERIAL MANAGEMENT PROGRAM

LOCATION AND VICINITY MAPS

DRAWN BY: PJO	CHECKED BY: KJW
DATE: 10 MAY 04	FIGURE 1



SITE PLAN

500 250 0 500 1000FT

SCALE: 1" = 500'

U.S. ARMY ENGINEER DISTRICT, DETROIT
CORPS OF ENGINEERS
DETROIT, MICHIGAN

UPPER SAGINAW RIVER, MICHIGAN

PROPOSED DREDGED MATERIAL PLACEMENT SITE (WEST)

SITE PLAN

DRAWN BY: PJO	CHECKED BY: KJW
DATE: 10 MAY 2004	FIGURE 2

NOTES:

1. THE TOTAL AREA OF THE SITE IS APPROXIMATELY 581 ACRES.
2. THE AREA OF THE PROPOSED (HACHURED) PLACEMENT AREA IS APPROXIMATELY 281 ACRES.
3. THE AREA OF THE PROPOSED MITIGATION AREA IS APPROXIMATELY 300 ACRES.

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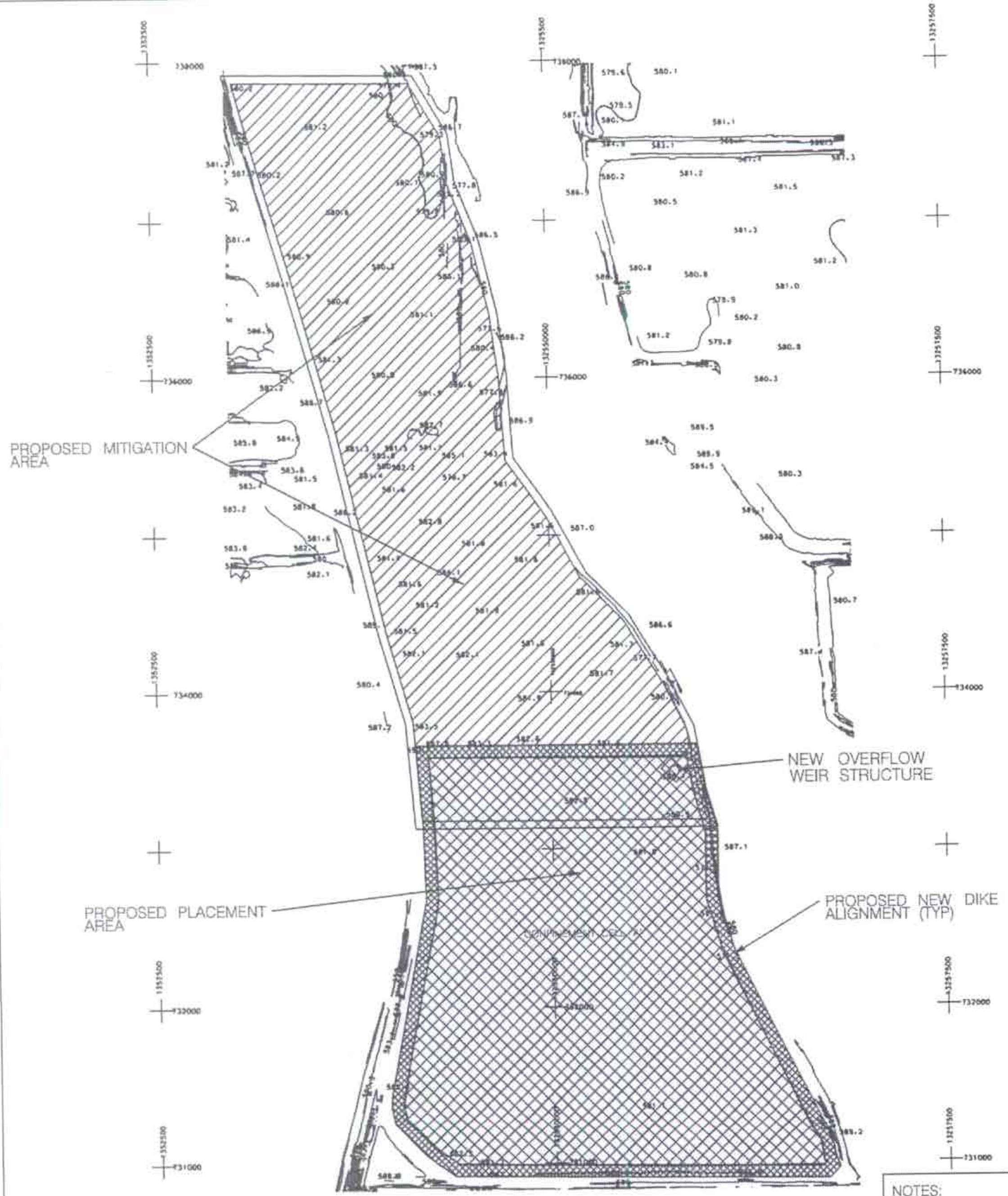


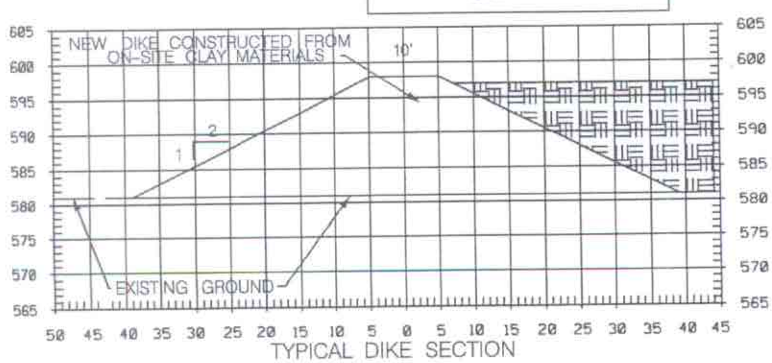
SITE PLAN

250 0 500 1000FT

SCALE: 1" = 500'

NOTES:

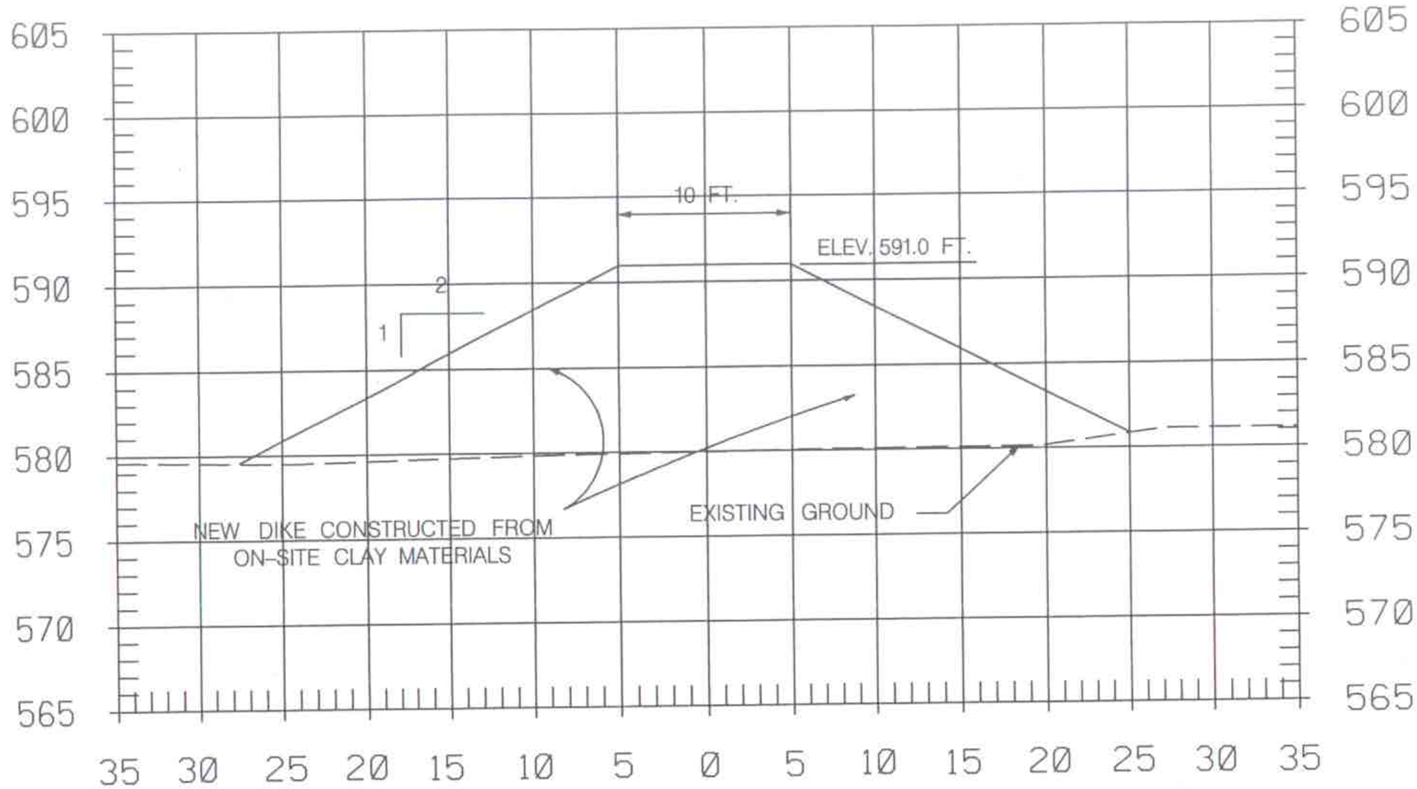
1. THE TOTAL AREA OF THE SITE IS APPROXIMATELY 274 ACRES.
2. THE AREA OF THE PROPOSED (HACHURED) PLACEMENT AREA IS APPROXIMATELY 131 ACRES.
3. THE AREA OF THE PROPOSED MITIGATION AREA IS APPROXIMATELY 143 ACRES.



TYPICAL DIKE SECTION

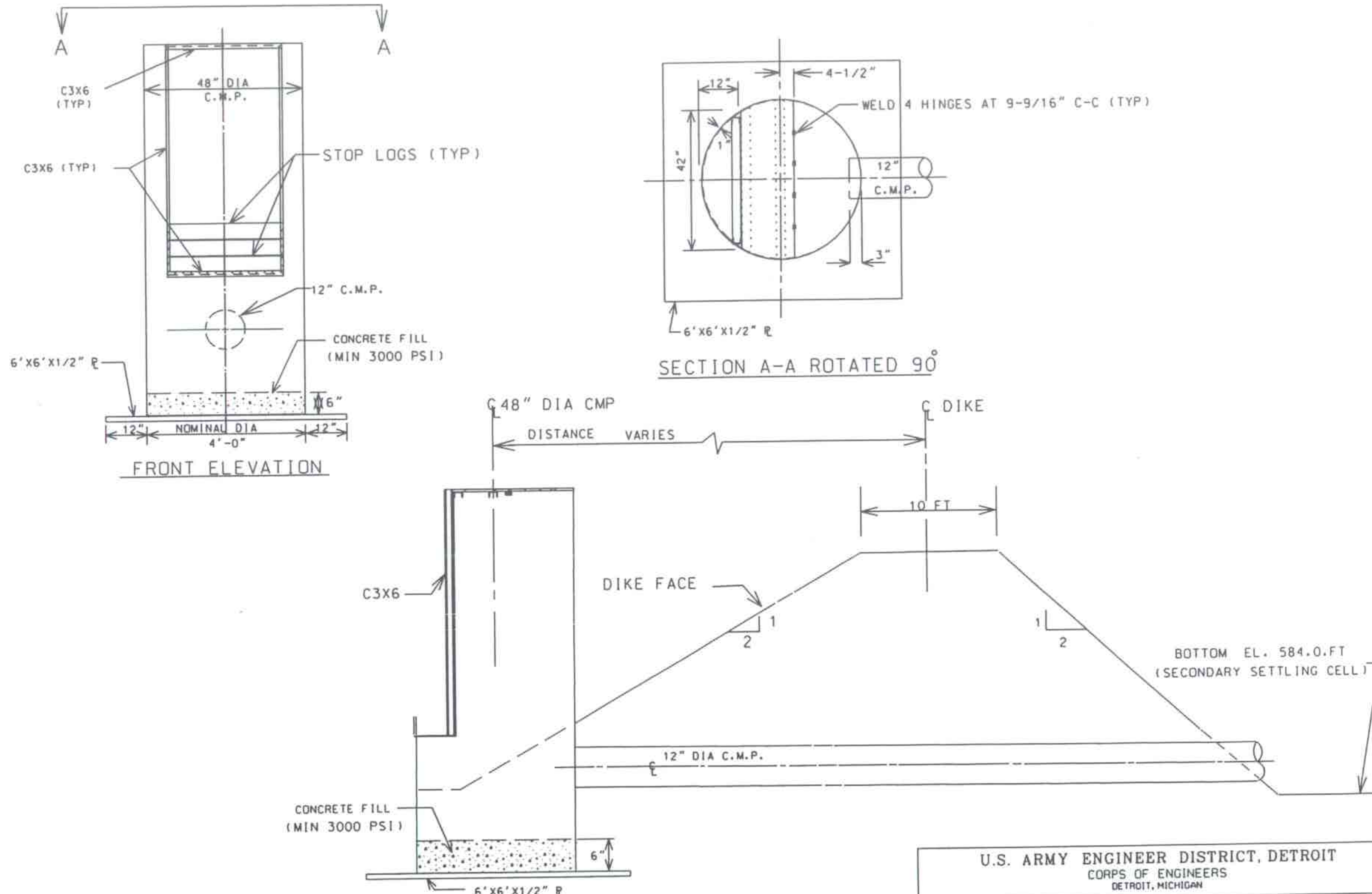
SCALE: 1" = 40'

U.S. ARMY ENGINEER DISTRICT, DETROIT CORPS OF ENGINEERS DETROIT, MICHIGAN	
UPPER SAGINAW RIVER, MICHIGAN PROPOSED DREDGED MATERIAL PLACEMENT SITE (EAST) SITE PLAN	
DRAWN BY: PJD	CHECKED BY: KJW
DATE: 10 MAY 2004	FIGURE 3



TYPICAL DIKE SECTION

U.S. ARMY ENGINEER DISTRICT, DETROIT CORPS OF ENGINEERS DETROIT, MICHIGAN	
UPPER SAGINAW RIVER, MICHIGAN DREDGED MATERIAL MANAGEMENT PROGRAM TYPICAL DIKE SECTION - WEST SITE	
DRAWN BY: PJO	CHECKED BY: KJW
DATE: 10 MAY 04	FIGURE 4



OVERFLOW WEIR

NO SCALE

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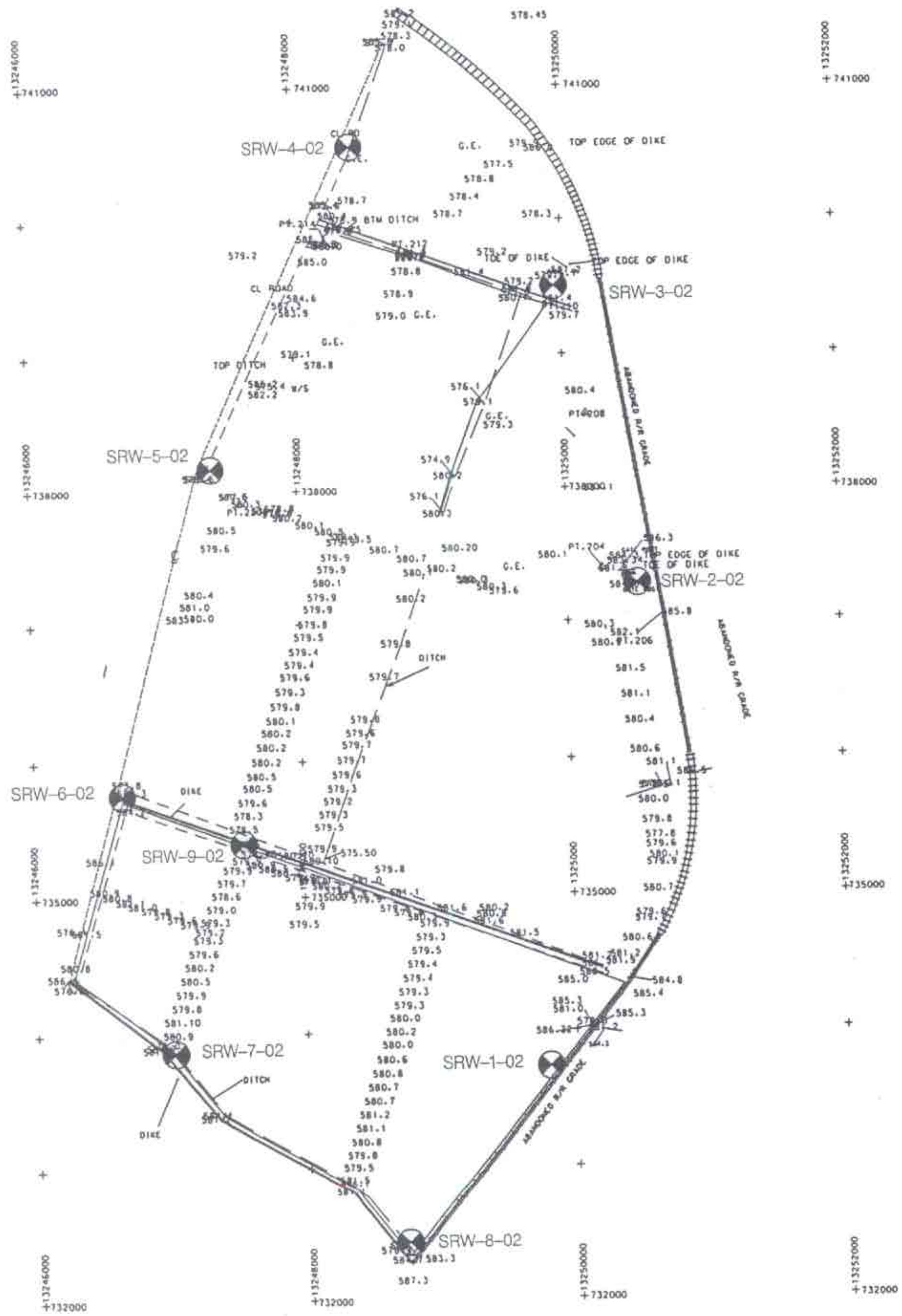
UPPER SAGINAW RIVER, MICHIGAN
DREDGED MATERIAL MANAGEMENT PROGRAM
OVERFLOW WEIR

DRAWN BY: PJO	CHECKED BY: KJW
DATE: 10 MAY 04	FIGURE 5



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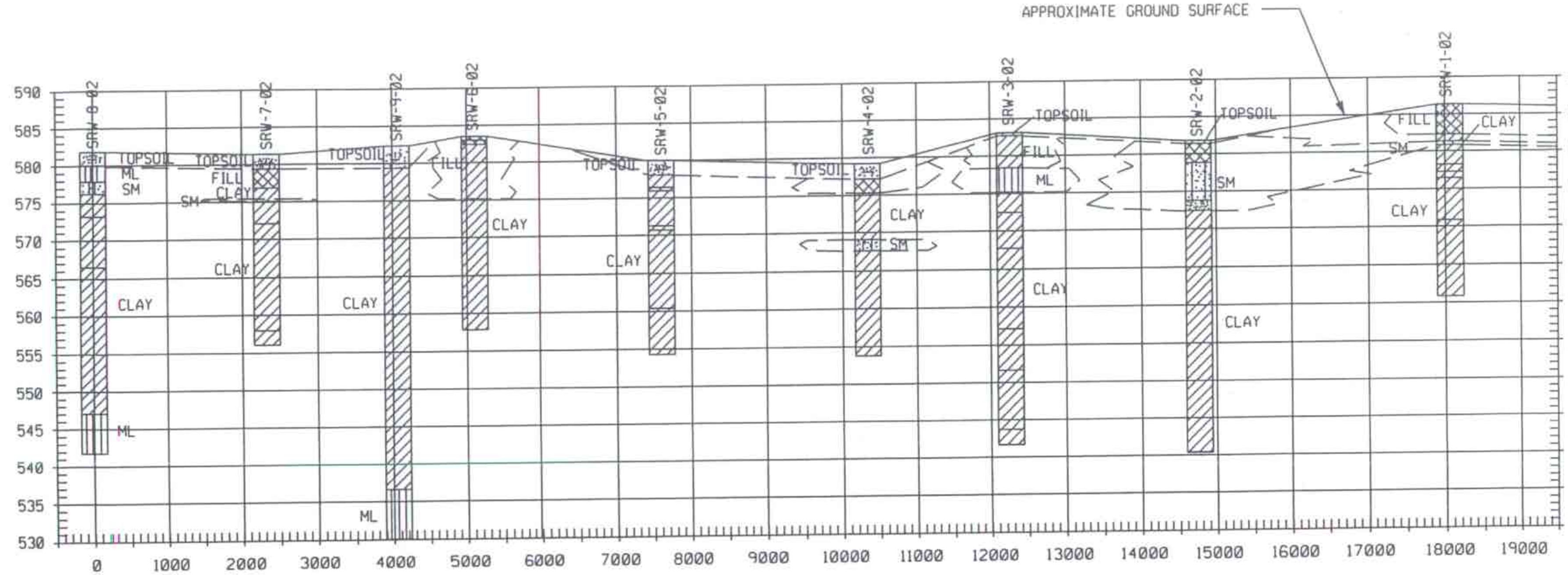
UPPER SAGINAW RIVER, MICHIGAN
DREDGED MATERIAL MANAGEMENT PROGRAM

SOIL BORING LOCATIONS - WEST SITE

DRAWN BY: PJO	CHECKED BY: KJW
DATE: 10 MAY 04	FIGURE 6



SOIL PROFILE

U.S. ARMY ENGINEER DISTRICT, DETROIT
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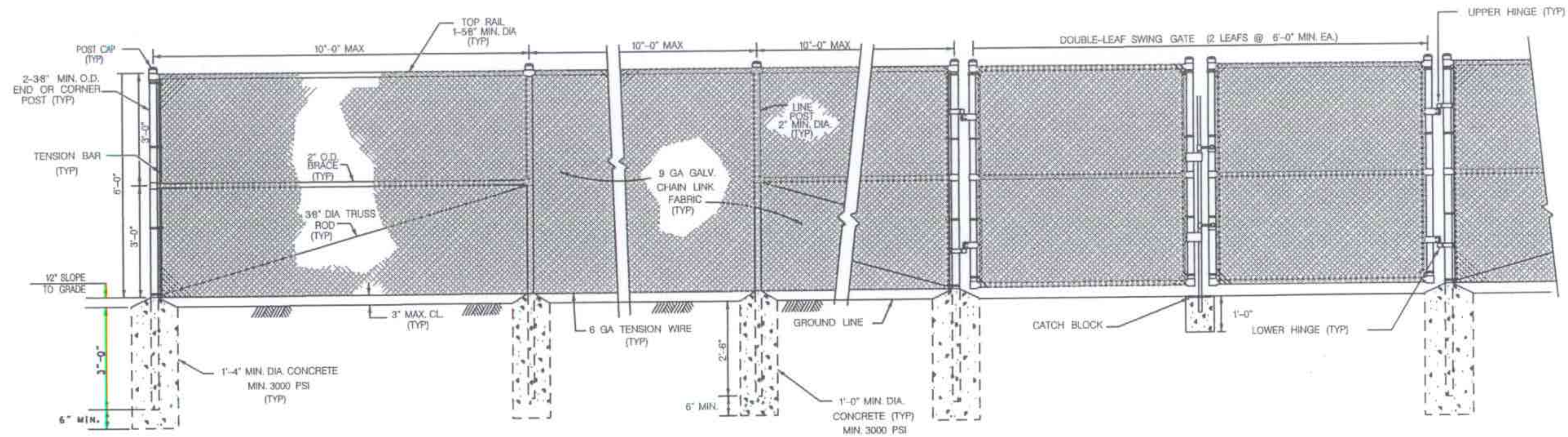
UPPER SAGINAW RIVER, MICHIGAN
DREDGED MATERIAL MANAGEMENT PROGRAM

SOIL PROFILE - BUENA VISTA SITE

DRAWN BY: PJO	CHECKED BY: KJW
DATE: 10 MAY 04	FIGURE 7



PERIMETER SECURITY FENCE

NOT TO SCALE

U.S. ARMY ENGINEER DISTRICT, DETROIT
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UPPER SAGINAW RIVER, MICHIGAN
DREDGED MATERIAL MANAGEMENT PROGRAM

SECURITY FENCE

DRAWN BY: PJO	CHECKED BY: KJW
DATE: 10 MAY 04	FIGURE 8

CALCULATIONS

COMPUTATION SHEET

PROJECT UPPER SAGINAW RIVER DMMP — SHEET NO. 1 OF 2 SHEETS

ITEM PLACEMENT AREA DESIGN — DATE 7/23/03

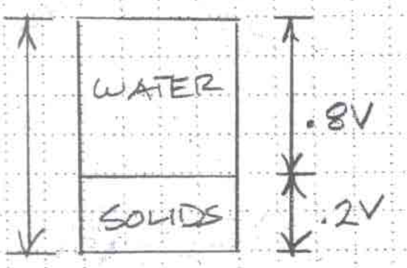
SUBJECT TYPICAL DISPOSAL CELL DIKE DESIGN — FILE

COMPUTED BY RJO — CHECKED BY — REF DRAWING NO.

GENERAL

THE DESIGN OF A TYPICAL CELL ASSUMES THE THE CAPACITY TO CONTAIN ONE SEASON OF ANNUAL MAINTENANCE DREDGING OF 150,000 CY PLUS THE TRANSPORT WATER.

FROM EXPERIENCE, ASSUME THAT THE DREDGED SEDIMENTS WILL CONTAIN 20% SOLIDS AND 80% WATER. BASED ON REMOVAL OF 150,000 CY OF IN-PLACE MATERIALS, THE TOTAL VOLUME OF SOLIDS & WATER IS:



$.2V + .8V = V_{TOT}$

WHERE $.2V = 150{,}000$ CY

$\Rightarrow 150{,}000 \text{ CY} + .8V = V_{TOT}$

$150{,}000 = V - .8V$

$\therefore V = \dfrac{150{,}000}{.2} = 750{,}000$ CY

THE AVAILABLE CONFINEMENT AREA = 281 ACRES THE RESULTING HEIGHT OF WATER/SOLIDS IS:

$$H = \frac{750{,}000 \text{ CY} \times 27 \text{ FT}^3/\text{CY}}{281 \text{ ACRES} \times 43{,}560 \text{ FT}^2/\text{ACRE}}$$

$= 1.65$ SAY 2.0 FT.

BECAUSE THE RELATIVELY LARGE AREA PERMITS THE RETENTION OF ALL OF THE TRANSPORT WATER, THE PONDING DEPTH AND FREEBOARD WILL BE ASSUMED TO BE EQUAL WHICH IS TYPICALLY 2.0 FT.

COMPUTATION SHEET

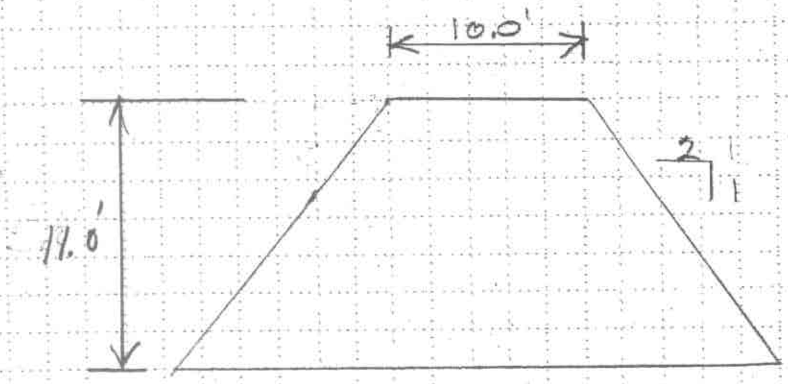
PROJECT: UPPER SAGINAW RIVER DMMP SHEET NO. 2 OF 2 SHEETS

ITEM: PLACEMENT AREA DESIGN DATE:

SUBJECT: TYPICAL DISPOSAL CELL DIKE DESIGN FILE:

COMPUTED BY: RJO CHECKED BY: REF DRAWING NO.:

THEREFORE THE TYPICAL DIKE SECTION ASSUMES A MINIMUM CREST WIDTH OF 10.0 FT AND SIDESLOPES OF 1 VERTICAL ON 2 HORIZONTAL, THE SIDESLOPE DIMENSIONS ARE BASED ON USING EXISTING ON-SITE MATERIALS FOR BORROW WHICH CONSISTS OF BROWN MEDIUM TO STIFF CLAY.



TYPICAL DIKE SECTION – NEW DIKE

THE AVERAGE DEPTH OF SOLIDS AFTER DEWATERING IS:

$$\frac{150{,}000\,CY \times 27\,FT^3/CY}{281\,ACRES \times 43{,}560\,FT^2/ACRE}$$

$= 0.3\,FT$

THE DESIGN LIFE OF THE CONFINEMENT SITE IS 20 YEARS. ASSUMING THAT BULKING AND CONSOLIDATION ARE EQUAL, THE FINAL HEIGHT OR DEPTH OF THE FILL IS:

$20\,YRS \times 0.33\,FT/YR = 6.0\,FT.$

THE FINAL DIKE HEIGHT THEREFORE EQUALS THE DEPTH OF FILL PLUS FREEBOARD FOR FLOODING PLUS FREEBOARD FOR INTERIOR WATER:

$H_D = 6.0 + 3.0 + 2.0 = 11.0\,FT$

COMPUTATION SHEET

PROJECT Upper Saginaw CDF - West

SUBJECT

ITEM Volume Calculations

COMPUTED BY RKP

CHECKED BY

DATE 12 May 2004

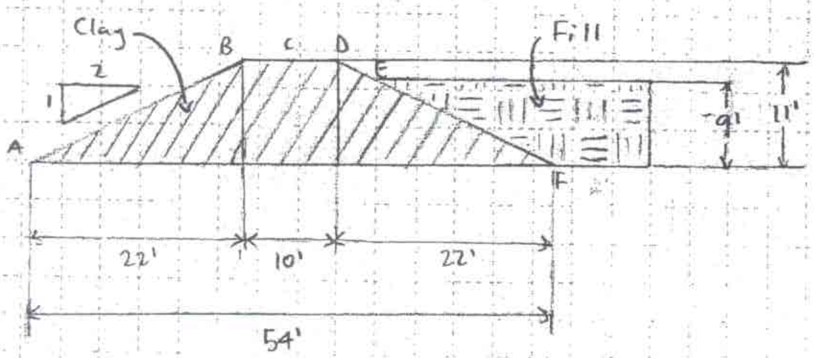
PAGE 1 OF 3

PAGE OF

REF

Dike Cross Section

Scale: 1" = 20'



Sectional Area (dike)

Area $= (22' + 10')(11') = 352\ ft^2$

Perimeters

A = 14,645'

F = 13,685'

C $= \frac{14,645' + 13,685}{2} = 14,165'$

E: $22' - (\frac{2}{1})(2') = 18'$

$\frac{18'}{54'}(14,645' - 13,685') + 13,685' = 14,005'$

Dike Volume

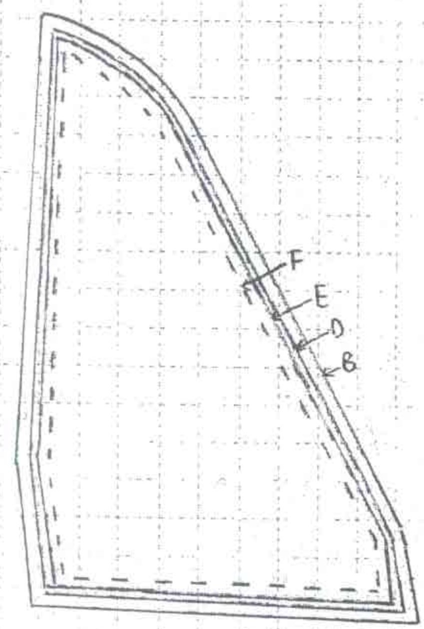
$(352\ ft^2)(14,165') = 4,986,080\ ft^3 = 184,670\ yd^3$

COMPUTATION SHEET

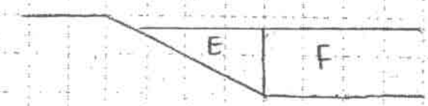
PROJECT Upper Saginaw CDF - West
SUBJECT
ITEM Volume Calculations
COMPUTED BY RKP CHECKED BY

DATE 12 May 2004
PAGE 2 OF 3
PAGE OF
REF

Confinement Cell
No Scale



Fill Section
No Scale



1 acre = 43,560 ft^2

Volume E

Area = $\frac{1}{2}(9')(18') = 81 ft^2$

Volume = $(81 ft^2)(\frac{1}{3}(14,645' - 13,685') + 13,685') = 1,134,405 ft^3 = 42,015 yd^3$

Volume F

Area = 240.2 acres = 10,463,112 ft^2

Volume = $(10,463,112 ft^2)(9') = 94,168,008 ft^3 = 3,487,704 yd^3$

Total Fill Volume

$42,015 yd^3 + 3,487,704 yd^3 = 3,529,719 yd^3$
$+ \quad 184,670 yd^3$ Dike Material Fill
$3,714,389 yd^3$

* Assuming Confinement Cell is flat and at equal elevation to bottom of dike.

COMPUTATION SHEET

PROJECT Upper Saginaw CDF - West

SUBJECT

ITEM Volume Calculations

COMPUTED BY RKP CHECKED BY

DATE 13 May 2004

PAGE 3 OF 3

PAGE OF

REF

<u>Topsoil Removement Adjustment</u>

Topsoil Removed $= (1')(80 \text{ acres}) = (1')(3{,}484{,}800 \text{ ft}^2) = 3{,}484{,}800 \text{ ft}^3 = 129{,}067 \text{ yd}^3$

$$\begin{array}{r} 3{,}714{,}389 \text{ yd}^3 \\ -\ 129{,}067 \text{ yd}^3 \\ \hline \boxed{3{,}585{,}322 \text{ yd}^3} \end{array}$$

total capacity of CDF

COMPUTATION SHEET

PROJECT Upper Saginaw CDF - East SHEET NO. 1 OF 3 SHEETS

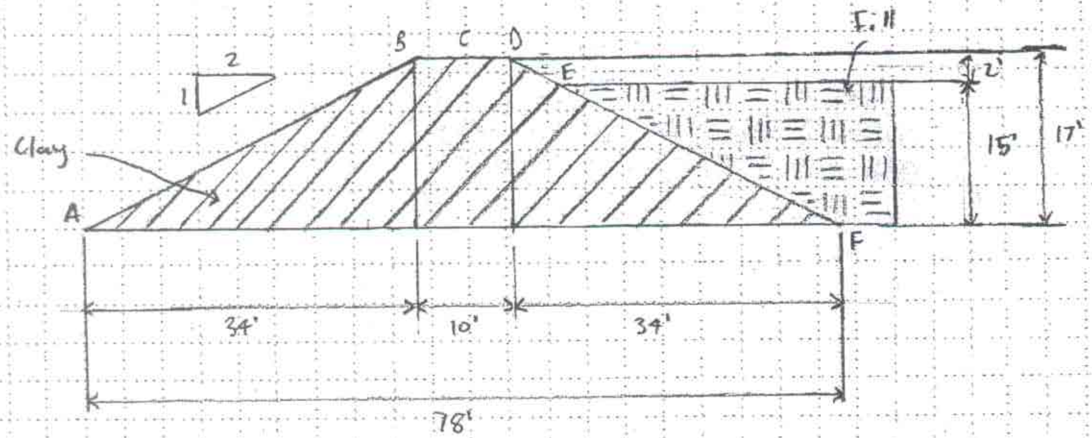
ITEM DATE 11 May 2004

SUBJECT Volume Calculations FILE

COMPUTED BY CHECKED BY REF. DRAWING NO.

Dike Cross Section

Scale: 1" = 20'



Sectional Area (dike)

Area = (34' + 10')(17') = 748 ft²

Perimeters

A = 10,080'

F = 9,511'

$C = \frac{10,080' + 9,511'}{2} = 9,796'$

$E = 34' - (\frac{2}{1})2' = 30'$

$\frac{30'}{78'}(10,080' - 9,511') + 9,511' = 9,730'$

Dike Volume

(748 ft²)(9,796') = 7,327,408 ft³ = 271,385 yd³

COMPUTATION SHEET

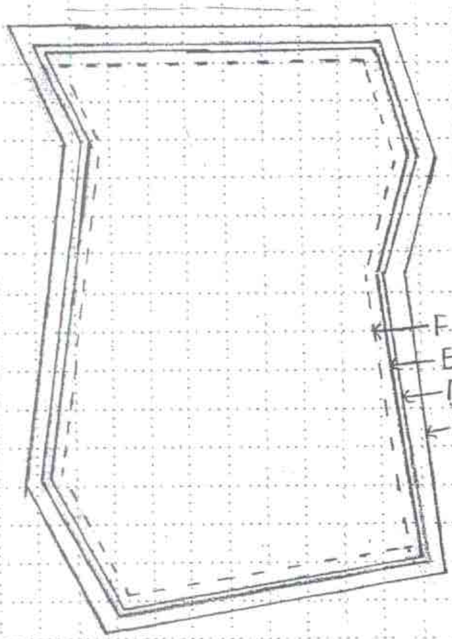
PROJECT Upper Saginaw CDF- East SHEET NO. 2 OF 3 SHEETS

ITEM DATE 12 May 2004

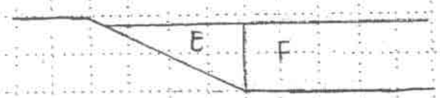
SUBJECT Volume Calculations FILE

COMPUTED BY CHECKED BY REF DRAWING NO.

Confinement Cell
No scale



Fill Section
No scale



1 acre = 43,560 ft²

Volume E

Area = ½(15')(30') = 225 ft²

Volume = (225 ft²)(⅓(9,730' − 9,511') + 9,511') = 2156,400 ft³ = 79,867 yd³

Volume F

Area = 119.6 acres = 5,209,774 ft²

Volume = (5,209,774 ft²)(15') = 78,146,610 ft³

Total Fill Volume

2156,400 ft³ + 78,146,610 ft³ = 80,303010 ft³ = 2,974,186 yd³
+ 271,385 yd³ Dike Material Fill
3,245,571 yd³

* Assuming Confinement Cell is flat, and at equal elevation to bottom of dike.

COMPUTATION SHEET

PROJECT Upper Saginaw CDF - East

SHEET NO. 3 OF 3 SHEETS

ITEM

DATE 12 May 2004

SUBJECT Volume Calculations

FILE

COMPUTED BY

CHECKED BY

REF DRAWING NO.

Topsoil Removement Adjustment

Topsoil Removed = $(1')(80 \text{ acres}) = (1')(3{,}484{,}800 \text{ ft}^2) = 3{,}484{,}800 \text{ ft}^3 = 129{,}067 \text{ yd}^3$

$$\begin{array}{r} 3{,}245{,}571 \text{ yd}^3 \\ -\ 129{,}067 \text{ yd}^3 \\ \hline \boxed{3{,}116{,}504 \text{ yd}^3} \end{array}$$

total capacity of CDF

SAGINAW RIVER PROPOSED CDF SITE
ZILWAUKEE, MICHIGAN

SLOPE STABILITY ANALYSIS

US ARMY CORPS OF ENGINEERS
DETROIT DISTRICT
CIVIL DESIGN SECTION

APRIL 2004

JPW 4/5/03

SAGINAW RIVER PROPOSED CDF SITE
ZILWAUKEE, MICHIGAN

SLOPE STABILITY ANALYSIS

1.0 General

This slope stability analysis is being done to obtain a CLOMA (Conditional Letter of Map Amendment).

2.0 Proposed Project

There are currently levees at an elevation of approximately 587 feet above LWD (NVGD 1929) around a portion of the proposed CDF. The 100-year flood elevation for this area is approximately 588, and FEMA requires a 3-foot freeboard. Therefore, levees for the proposed CDF require a top elevation of 591 feet above LWD.

Instead of building on the old levees, new levees are being constructed on the interior of the old levees (see Figure 1). Material within the proposed CDF will be used as a borrow source.

3.0 Site Geology

Material at the proposed site consists of brown medium to stiff silty clay with varying amounts of silt, sand, and gravel. The clay extends approximately 25 to 60 feet below ground surface. Some silt and silty clay can be found near the surface. A soil profile and geotechnical investigation prepared by STS Consultants is provided as an attachment.

After stripping the topsoil from the surface of the borrow area, the clay from the interior of the proposed CDF will be used as a borrow source for the new levee construction. Two compaction curves done on composite samples showed optimum moisture content of 10.5 and 14.5. The median in-situ moisture content varies from 10% to 35%, with a median value of 19%. Since the on site materials are wet of optimum, it will likely be necessary to implement moisture control measures during construction. The site has a pumping system that is used to control water levels during crop growing seasons that could be used for that purpose. Simpler methods, such as digging trenches through the borrow area and pumping the water that collects, may also be useful.

JPL

4.0 Slope Stability Analysis

Three conditions were analyzed during the slope stability analysis, as discussed below. A normal load of 200 psf was used on the levee crest to account for vehicle loads on the levee during construction, operation, and maintenance of the CDF.

4.1 End of Construction Condition:

Undrained shear strengths determined from Unconsolidated, Undrained (UU, or Q) Tests, as well and Unconfined Compression (UC) were used to determine total stresses. The average shear strength value minus ½ the standard deviations for the UU and UC tests were very comparable at 1078 and 1071 psf. A phi = 0, c=1000 psf analysis was run. This is a conservative assumption that the soil will be saturated and not rely on any frictional strength between soil particles. Even with this conservative assumption, a factor of safety of 4.8 was obtained.

4.2 Steady State Seepage at flood level

This scenerio describes a long-term condition in which steady state seepage has been allowed to occur after water levels have increased to the 100 year flood stage. Direct shear test results were used to determine the effective shear strength of the soil (300 pcf). Again, a phi = 0 was used. A factor of safety of 2.0 was obtained. A steady state seepage was also analyzed at a water level of 586, and had a factor of safety of 1.7

4.3 Sudden Drawdown after flood level

Sudden Drawdown conditions assume that after the system has reached steady state seepage at the flood stage of 588 feet above LWD, the water level will drop faster than the soil can drain. Effective stresses and phi = 0 was used in this analysis. This was the most critical analysis, with a factor of safety of 1.5.

Table 1: Slope Stability Results

Analysis	Unit Weight	Cohesion	Angle of Internal Friction	Water elevation	Factor of Safety	Minimum required[1]
End of Construction	115 pcf	1000 pcf	0	583	4.8	1.3
Steady State Seepage at flood level	115	300 (effective)	0	588	2.0	1.4
Steady State at H20 - 586	115	300 (effective)	0	586	1.7	1.4
Sudden Drawdown	115	300 (effective)	0	583	1.5	1.0

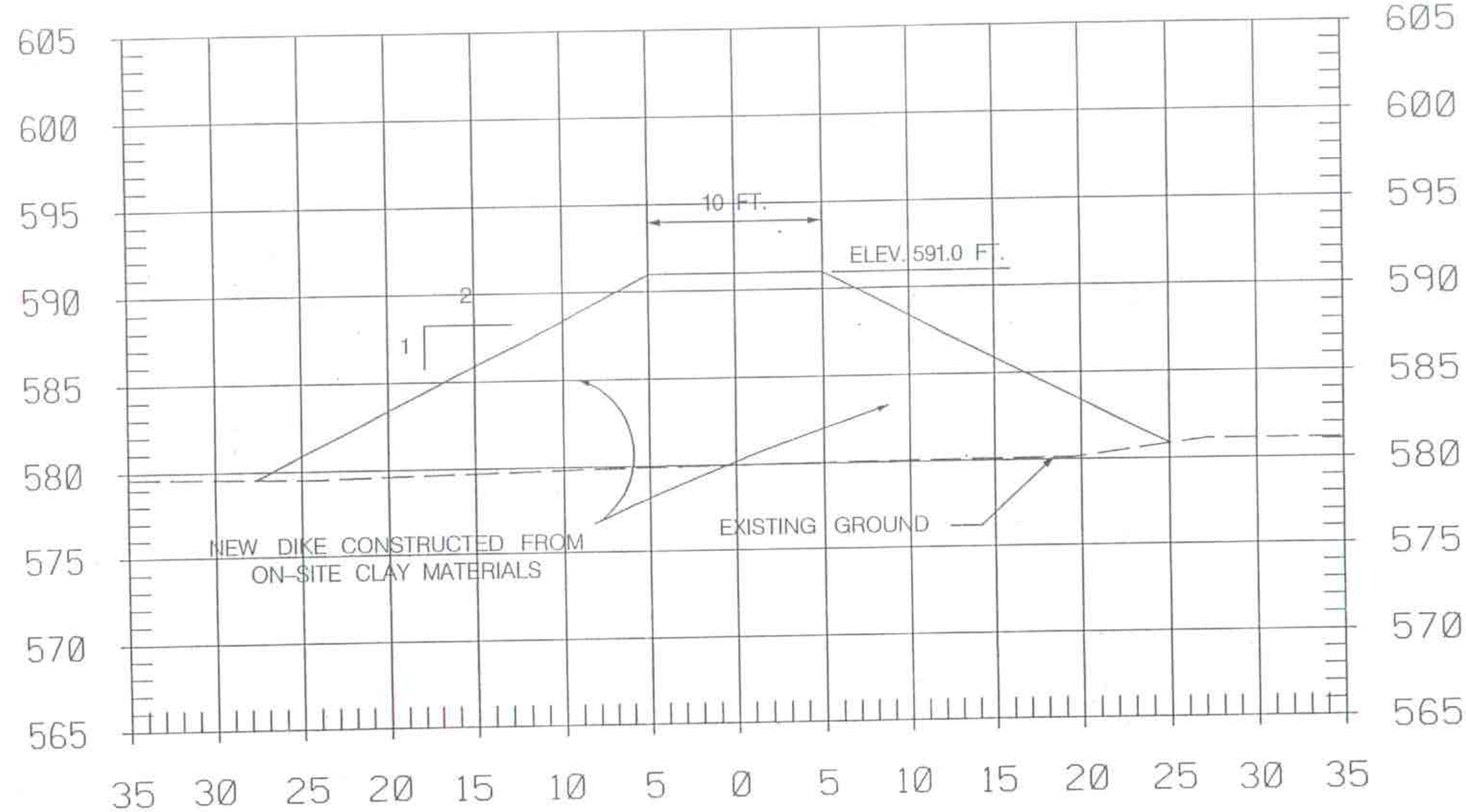
1. EM-1110-2-1913, Table 6-1b

5.0 Hydrocompaction:

Hydrocompaction is subsidence due to the compaction of soils through the loss of water. This can be significant in loose soils. Hydrocompaction is not an issue at this site, since we are requiring 90% maximum density compaction. In addition, the clays have a low PI, and are not high swelling clays.

6.0 Conclusions:

The designed levee cross-section meets all minimum factors of safety for end of construction, steady state seepage, and sudden drawdown conditions. On site borrow material is wet of optimum, and moisture control will need to be implemented to reach the recommended compaction to 90% of maximum density. This analysis assumes that the levees will be properly maintained. Animal burrows and trees can significantly impact the stability of the levee slopes.



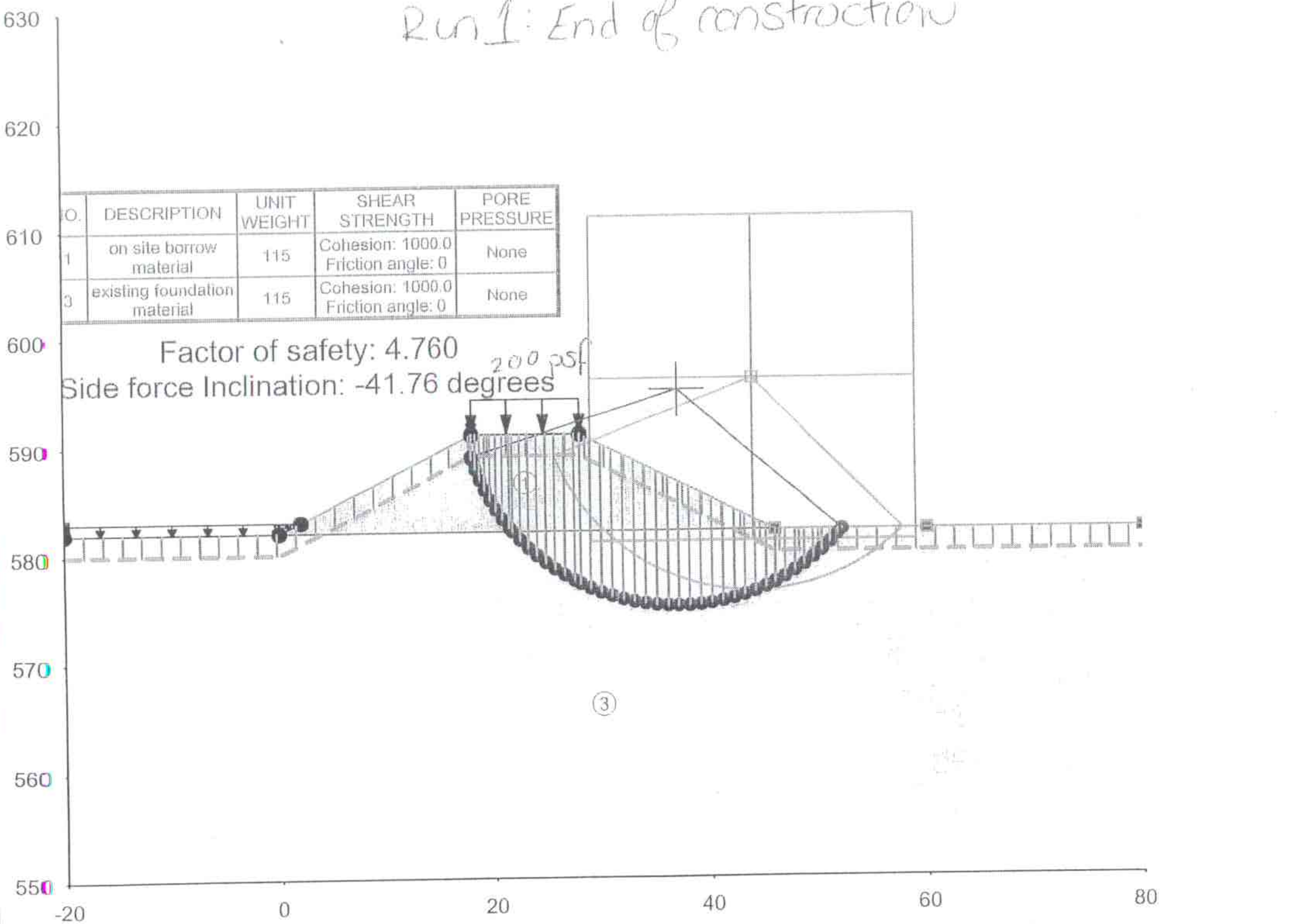
TYPICAL DIKE SECTION

U.S. ARMY ENGINEER DISTRICT, DETROIT CORPS OF ENGINEERS DETROIT, MICHIGAN	
UPPER SAGINAW RIVER, MICHIGAN DREDGED MATERIAL MANAGEMENT PROGRAM TYPICAL DIKE SECTION – WEST SITE	
DRAWN BY: PJO	CHECKED BY: KJW
DATE: 10 MAY 04	FIGURE 1

...\uppersag\typicalsec.dgn 07/07/2004 08:39:47 AM

Saginaw River CDF

Run 1: End of construction



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	on site borrow material	115	Cohesion: 1000.0 Friction angle: 0	None
3	existing foundation material	115	Cohesion: 1000.0 Friction angle: 0	None

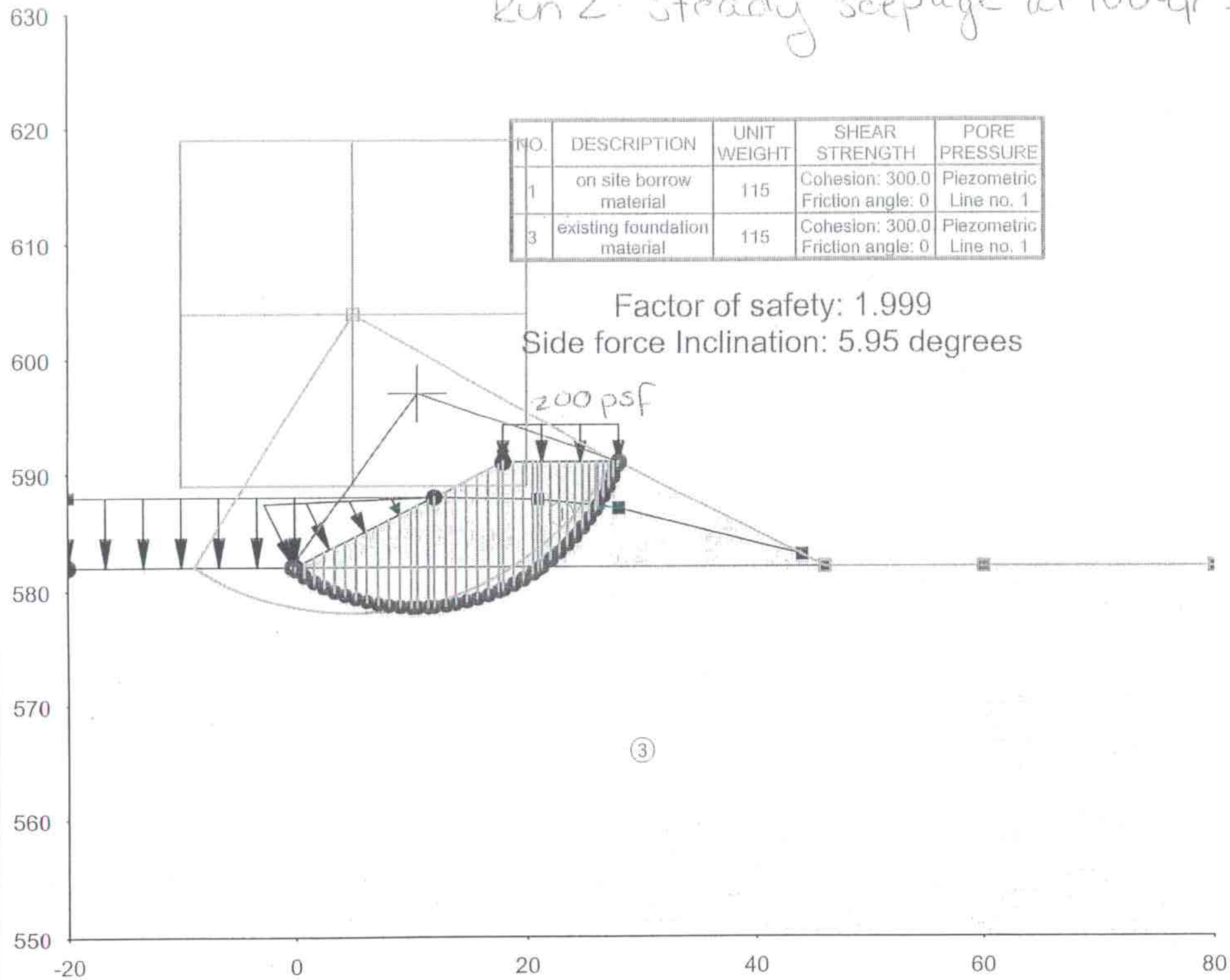
Factor of safety: 4.760

Side force Inclination: -41.76 degrees

Date: Wed Apr 07Filename: U:\CIV DESIGN PROJECTS\SaginawCDF\UTEXASrevload\EndofConstruction.UT4 Time: 12:59:02

Saginaw River CDF

Run 2: Steady Seepage at 100-yr flood

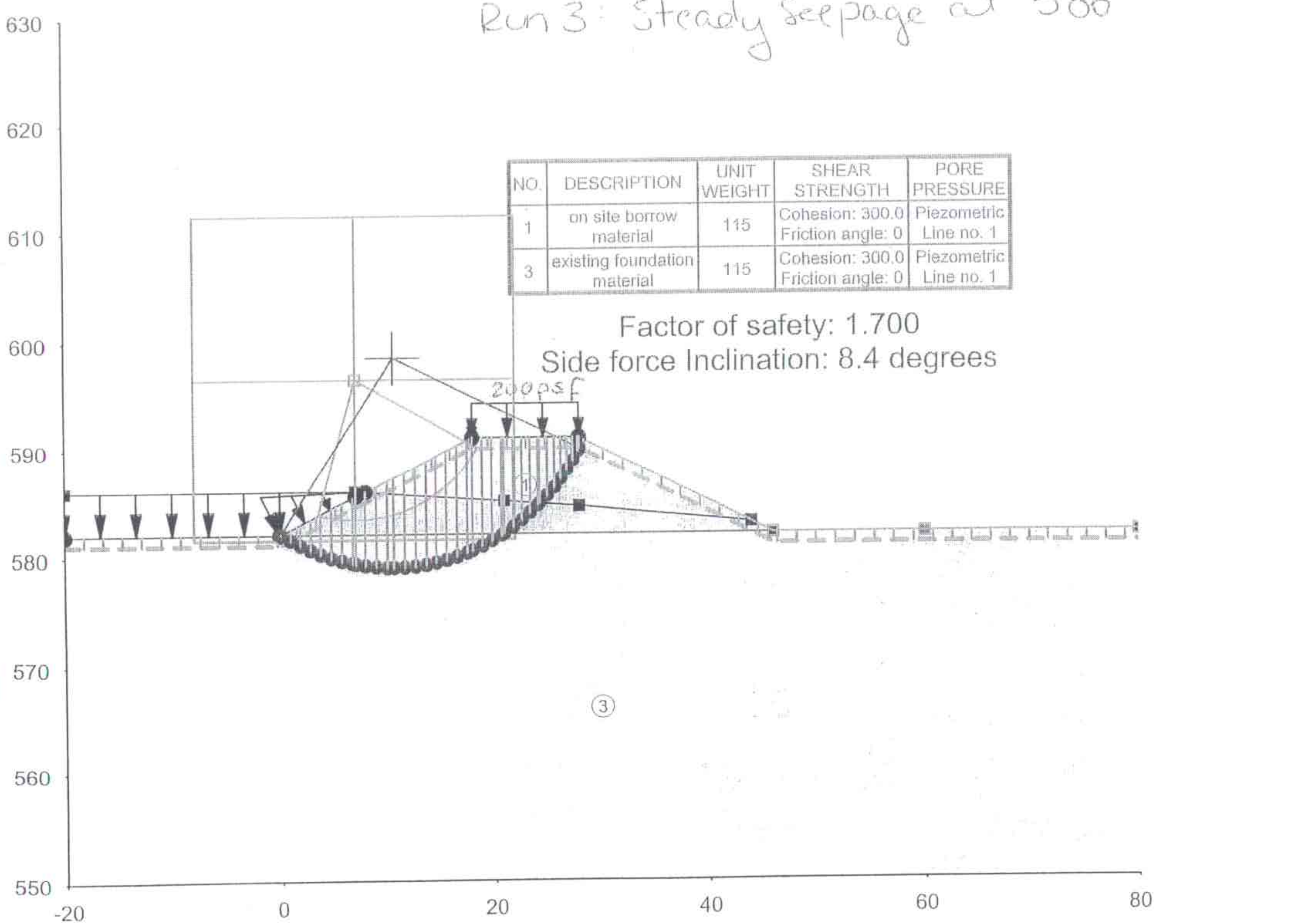


NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	on site borrow material	115	Cohesion: 300.0 Friction angle: 0	Piezometric Line no. 1
3	existing foundation material	115	Cohesion: 300.0 Friction angle: 0	Piezometric Line no. 1

Date: Wed Apr 07 Filename: U:\CIV DESIGN PROJECTS\SaginawCDF\UTEXASrevload\Steady Seepage.UT4 Time: 12:52:49

Saginaw River CDF

Run 3: Steady Seepage at 586'



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	on site borrow material	115	Cohesion: 300.0 Friction angle: 0	Piezometric Line no. 1
3	existing foundation material	115	Cohesion: 300.0 Friction angle: 0	Piezometric Line no. 1

Date: Wed Apr 07Filename: U:\CIV DESIGN PROJECTS\SaginawCDF\UTEXASrevload\Steady Seepage3.UT4 Time: 12:54:32

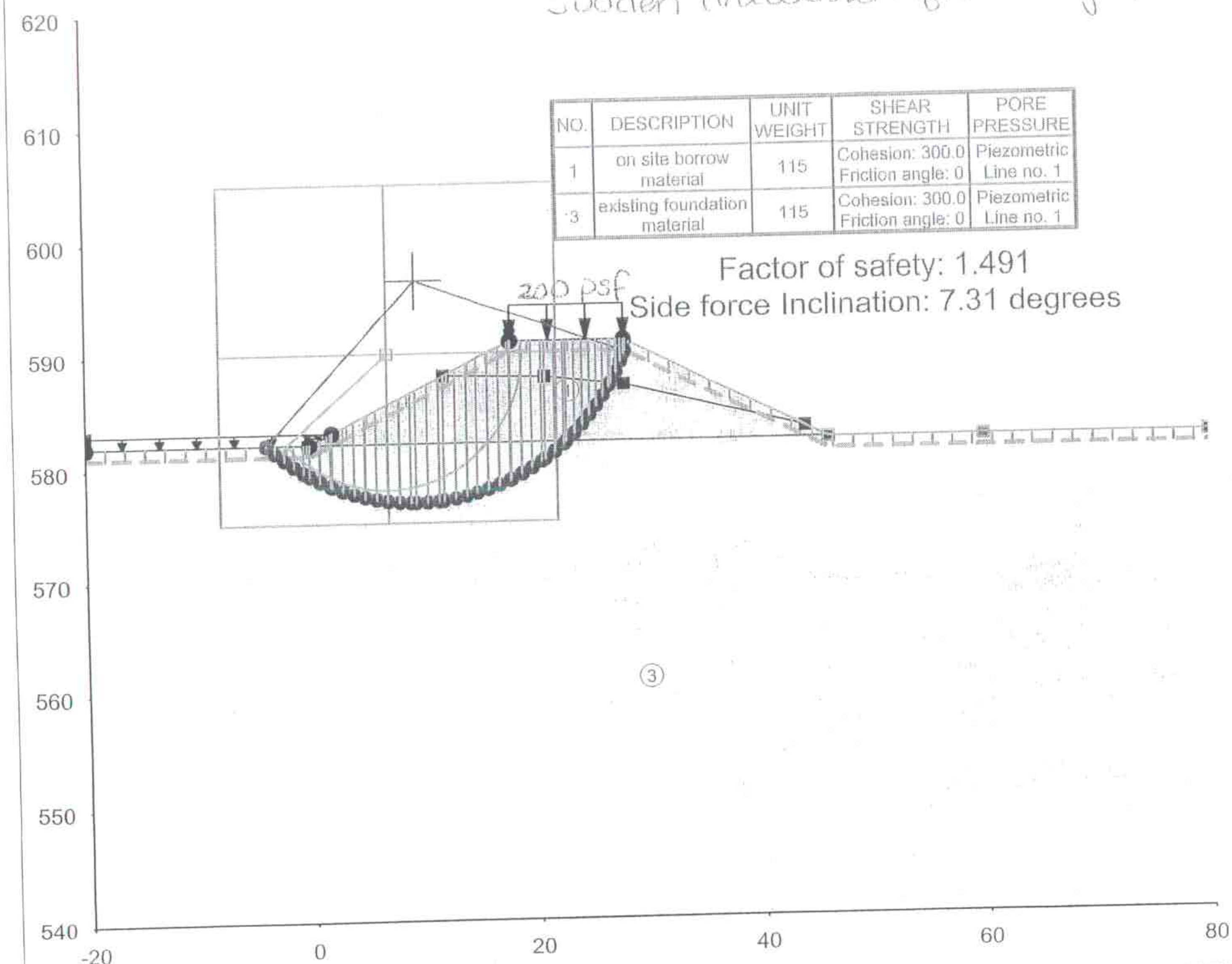
Saginaw River CDF - Run 4

Sudden drawdown after 100-yr flood

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	on site borrow material	115	Cohesion: 300.0 Friction angle: 0	Piezometric Line no. 1
3	existing foundation material	115	Cohesion: 300.0 Friction angle: 0	Piezometric Line no. 1

Factor of safety: 1.491

Side force Inclination: 7.31 degrees



Date: Wed Apr 0Filename: U:\CIV DESIGN PROJECTS\SaginawCDF\UTEXASrevload\SUdden Drawdown3.UT4Time: 12:55:09

A-24

5.0 EXPLORATION RESULTS

5.1 Site Activities

The STS engineer and drillers mobilized to the site on July 30, 2002. Drilling and sampling began on July 30th and continued until August 1st. Drilling activities began at the proposed eastern disposal site location where a total of seven borings were drilled and sampled. Four borings were drilled to 25.0 feet, two borings to 40.0 feet and one boring was drilled to 60.o feet. Once the borings were complete the drill rig was loaded on the trailer and mobilized to the proposed western disposal site location. Nine borings were completed on the western side of the Saginaw River. Six borings were drilled to 25.0 feet, two borings to 40.0 feet and one boring was drilled to 60.0 feet. Six Photographs documenting portions of the field activities are presented in Appendix B.

5.2 Site Conditions

The proposed disposal areas for the Saginaw River sediments are located in Zilwaukee/Buena Vista Townships, Saginaw County, Michigan. Figure 2 illustrates the approximate location of the two proposed containment dike locations. The sites are approximately 0.5 mile northeast of Zilwaukee, Michigan. The elevations at the east site range from approximately 580.0 to 587.8 feet. The elevations at the west site range from approximately 579.3 to 585.7 feet.

5.3 Soil Conditions/Site Comparison

5.3.1 East Site

Four of the seven borings performed on the east site were drilled within the existing dike system. The soil borings were SRE-10-02, SRE-11-02, SRE-14-02 and SRE-16-02. A general description of the fill and natural soil types encountered includes:

TOPSOIL

Topsoil was encountered in borings SRE-14-02 and SRE-16-02 with thicknesses of 1.0 and 0.4 feet. The topsoil typically consists of sand with varying amounts of silt, clay and gravel with trace roots.

FILL - SAND & GRAVEL

Fill material was encountered while drilling on access roads and on the existing dike system at the east site. At borings SRE-10-02 and SRE-11-02, the fill material consisted of brown medium to coarse gravel with thicknesses of 2.0 feet at each location. The fill material at SRE-10-02 contained broken pieces of red brick or possibly broken pottery shards. A 1.25 foot layer of fine silty sand with trace roots and clay was encountered in the dike (SRE-10-02) at 5.0 feet. Boring SRE-14-02 was drilled on the dike system and contained brown fine silty sand with trace amounts of clay beneath the topsoil. The fill sand extended from a depth of 1.0 to 4.0 feet.

FILL - CLAY

Very stiff to hard silty clay fill (dike material) was encountered in borings SRE-10-02, SRE-11-02, and SRE-16-02 from 2.0 to 8.0 feet. The clay was brown to gray and contained varying amounts of silt, sand and gravel and occasionally small white shells. Boring SRE-14-02 encountered the very stiff to hard clay at 4.0 feet and the fill layer extended to 8.0 feet.

NATURAL SOILS

Cohesive Soils

Brown medium to stiff silty clay was encountered in all seven of the borings completed at the east site. The clay was brown to gray with varying amounts of silt, sand and fine gravel. The clay extends to approximately 25.0 feet in borings SRE-10-02, SRE-11-02, SRE-15-02 and SRE-16-02. Mottled and fractured silty clay was encountered within the silty clay in borings SRE-9-02, SRE-10-02 and SRE-11-02 at depths of 8.0 to 15.0 feet. The brown silty clay extended to 40.0 feet in borings SRE-9-02 and SRE-14. At boring location SRE-13-02, gray silty clay with a soft consistency was encountered at approximately 35.0 feet and extended to the termination depth of the boring at 60 feet.

Granular Soils

Two borings (SRE-15-02 and SRE-16-02) contained brown to black fine silty sand with trace amounts of roots, clay and occasional gravel. The natural sand encountered in borings SRE-15-02 and SRE-16-02 was at a depth of 8.0 feet and was approximately 2.0 feet thick.

5.3.2 West Site

Five of the nine borings performed on the west site were drilled within the existing dike system. These soil borings were SRW-1-02, SRW-3-02, SRW-4-02, SRW-6-02 and SRW-7-02. A general description of the fill and natural soil types encountered include:

TOPSOIL

Topsoil was encountered within all of the west site borings except SRW-1-02 and SRW-6-02. The topsoil typically consists of sand with varying amounts of silt, clay and gravel with trace roots. The minimum thickness of topsoil (0.3 feet) occurred at boring location SRW-2-02 and the maximum thickness (2.0 feet) occurred at SRW-4-02.

FILL - SAND & GRAVEL

Fill material was also encountered while drilling on access roads and on the existing dike system on the west site. Borings SRW-1-02 ~~and SRW-6-02 were~~ the only locations where gravel fill was encountered at the surface with thicknesses of 0.5 ~~and 2.8 feet respectively~~. Fill material consisted of brown medium to coarse sand and gravel at both locations with trace pieces of slag at SRW-1-02.

corrected profile.

FILL - CLAY

Silty clay fill (dike material) with a consistency of very stiff to hard was encountered in borings SRW-1-02, SRW-3-02, SRW-4-02, SRW-6-02 and SRW-7-02. The clay which was encountered below the topsoil and gravel fill was brown to gray and contained varying amounts of silt, sand and gravel and occasionally small white shells. Small lenses of sand and/or softer clay were sometimes encountered within the very stiff clay. The clay fill extended to a depth of approximately 8.0 feet at SRW-4-02, SRW-6-02 and SRW-7-02 and 6.0 feet at SRW-1-02 and SRW-3-02.

NATURAL SOILS

Cohesive Soils

Brown medium to stiff silty clay was encountered in all nine of the borings on the east site. The clay was brown to gray with varying amounts of silt, sand and fine gravel. The clay extends to approximately 25.0 feet in borings SRW-1-02, SRW-2-02, SRW-4-02, SRW-5-02, SRW-6-02 and SRW-7-02. Mottled and fractured silty clay was encountered within the silty clay in borings SRW-1-02, SRW-2-02 and SRW-6-02 at 8.0 feet with thicknesses of 1.0, 6.0, and 5.0 feet, respectively. The brown medium silty clay extended to 40 feet in borings SRW-3-02 and SRW-8-02. At boring location SRW-9-02, brown soft silty clay was encountered at approximately 35.0 feet and was 10.0 feet thick. Brown silty clay (or possibly clayey silt) with a very soft consistency extended from 45.0 to 60.0 feet.

Granular Soils

One boring (SRW-2-02) contained gray fine to medium sand with varying amounts of roots, silt, clay and occasional small white shells. The sand was encountered at a depth of 2.0 feet and was 7.0 feet thick.

The generalized soil profile described above is noted on the respective boring logs included in the Appendix B. Please refer to those logs for a more detailed description of the soils encountered at specific boring locations. Geologic profiles of the soils encountered at the east and west sites have been included as Figures 4 and 5.

5.4 Groundwater Table Conditions

Groundwater level readings were obtained in each boring during and after drilling and sampling operations. The groundwater elevations varied considerably across both proposed sites. The groundwater on the eastern side of the Saginaw River ranged from 8.5 to 20.0 feet below ground surface while drilling. Three of the seven boring locations did not encounter water while drilling and sampling. The groundwater on the western side of the Saginaw River ranged from 5.0 to 24.3 feet below ground surface while drilling. Three of the nine boring locations did not encounter water while drilling and sampling. Groundwater levels encountered at each boring location are located on the boring logs included in Appendix A. It should be noted, however, that groundwater levels obtained from soil borings may not reflect the natural long-term elevation of the groundwater table. Monitor wells would be required if more accurate or long-term monitoring of the groundwater levels is required.

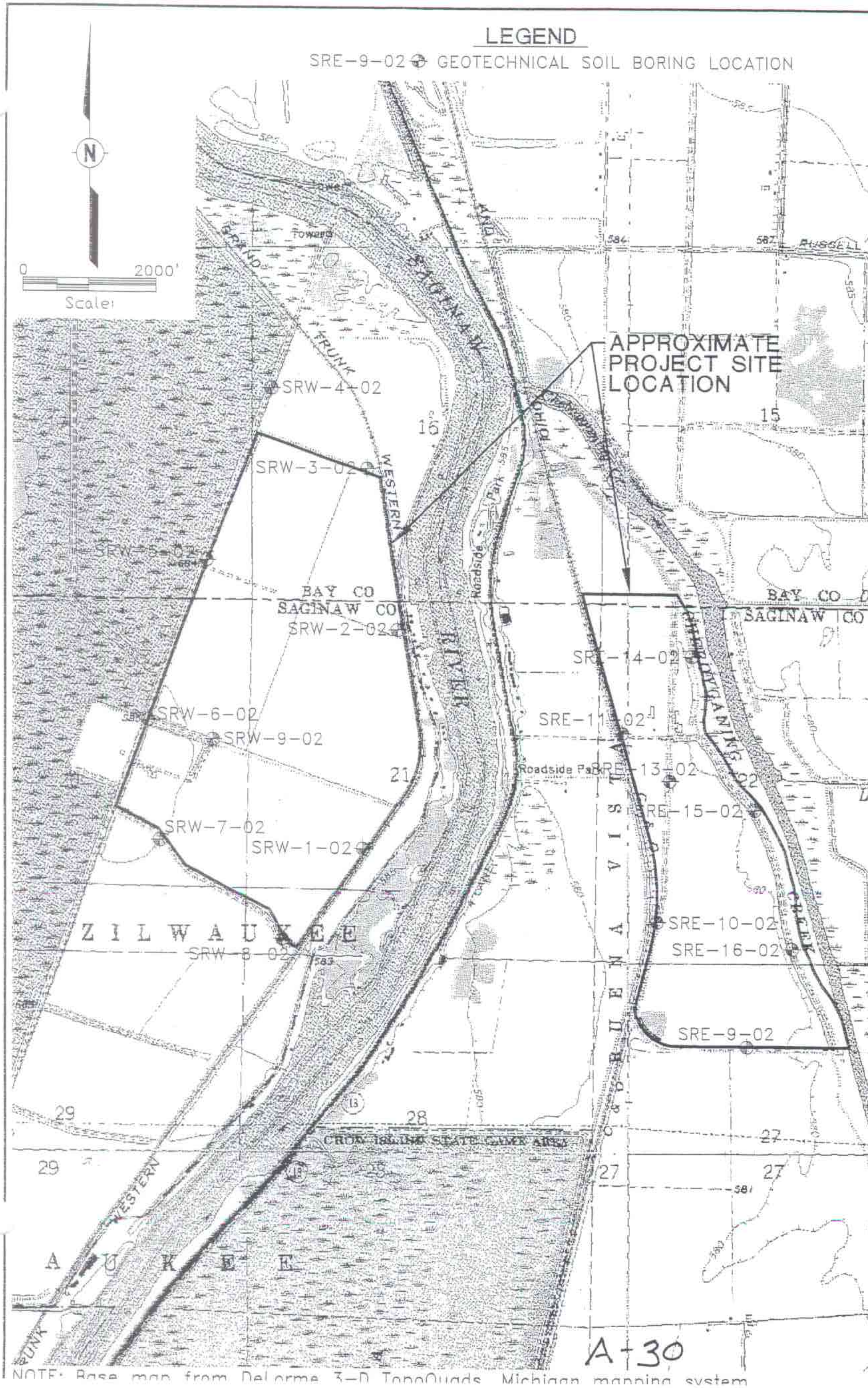
6.0 GENERAL QUALIFICATIONS

The analysis and recommendations submitted in this report are based on data obtained from soil borings. Variations can occur between these borings; the nature and extent of which may not become evident until after construction. If variations are encountered, it may be necessary to make a re-evaluation of the recommendations of this report after making on-site observations and noting characteristics of these variations.

Water level readings have been made in the borings at the time and under the conditions stated on the boring logs. This data has been reviewed and an interpretation made in the text of this report. However, it must be noted that the period of observation was relatively short, and that seasonal and annual fluctuations in the level of the groundwater will likely occur.

This report has been prepared in accordance with generally accepted soil and foundation engineering practices to aid in the evaluation of this property, and to assist the Agency and their Engineer in the design of this project. No other warranty, expressed or implied, is made. The scope of this report is limited to the specific project and location described herein, and our description of the project represents our understanding of the significant aspects relevant to soil and foundation characteristics. In the event any changes in the design or location of the structures as outlined in this report are planned, we should be informed so the changes can be reviewed, and the conclusion of this report modified and approved in writing by the Geotechnical Engineer.

As a check, we recommend that STS be authorized to review project plans and specifications to confirm that the recommendations of this report have been interpreted in accordance with our intent. Without this review, STS Consultants will not be responsible for misinterpretation of our data, our analyses, and/or our recommendations or how these are incorporated into the final design.



NOTE: Base map from DeLorme 3-D TopoQuads, Michigan mapping system

DRAWN BY CJD	DATE 09\18\02
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APPROVED BY	DATE
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GEOTECHNICAL SOIL BORING LOCATIONS
GEOTECHNICAL EVALUATION
SAGINAW RIVER
U.S. ARMY ENGINEER DISTRICT - DETROIT
ZILWAUKEE, MICHIGAN

STS Consultants Ltd.
Consulting Engineers

STS PROJECT NO. 74062

STS PROJECT FILE 74062

SCALE 1"=2000'

FIGURE NO. 2

A-30